Video and Image Retrieval and Analysis Tool (VIRAT) Industry Day

Dr. Mita Desai

March 27, 2008

Briefing to Industry for BAA 08-20
Arlington VA

Making visual-input search as easy as text-input

Industry Day Agenda

0900 Opening Remarks (Dr. Desai)

0905 Security Issues (Mr. Fisher)

0915 VIRAT Program Overview (Dr. Desai)

1000 Contracting Details (Mr. Glista)

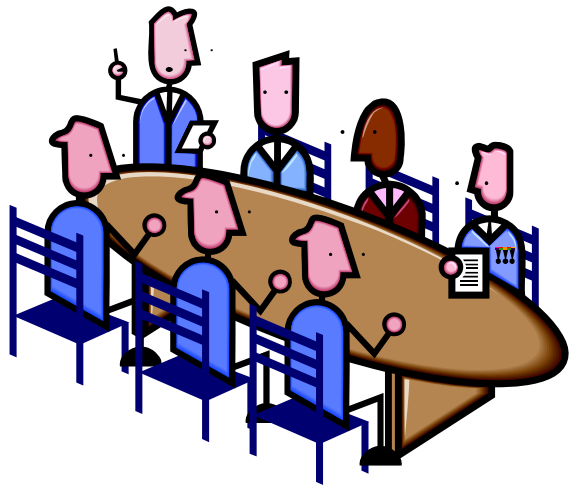
1015 Break

1045 Q&A (All)

1200 Adjourn

- **THIS MEETING IS SET AT THE UNCLASSIFIED LEVEL ONLY AND THERE WILL BE NO CLASSIFIED DISCUSSIONS**

- **PARTICIPANTS**
  - **U.S. INDUSTRY**
  - **U.S. DOD AGENCIES**
  - **UNIVERSITIES**
  - **FOREIGN NATIONALS**



- **PROPOSAL SUBMISSIONS**
  - -- UNCLASSIFIED / CLASSIFIED
- **PERFORMER RESPONSIBILITIES**
  - -- ITAR
  - -- PROTECTING THE INFORMATION

DARPA Security Points Of Contact

- **PROGRAM SECURITY REPRESENTATIVE**

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VIRAT Program Overview

- Program Vision
- Military Challenge
- Technologies Sought
- Program Structure
- Program Metrics

Content-Based Cuing from Streaming Video and Retrieval from Archived Videos

Given an example clip or image, find similar activities, events, activity patterns, scenes, and objects

Activity Alerts

(Cuing from Streaming Video)

Search and Retrieval

(Archived Videos)

Monitoring – fixed location of interest

- When did tanker trucks drive down this highway?
- Alert me when cars are seen stopping along this highway?
- When did someone enter this building?
- Alert me when a person is seen moving across this bridge?

Discovery – large area of interest

- Where were people digging holes?
- When and where were more than 5 people gathered together?
- When and where did an explosion occur?
- Where were all the trucks (parked or moving)?

Searching by visual content, not just time or location

VIRAT will focus on Activities

Action or Event	A single, low-level spatiotemporal entity that cannot be further decomposed • e.g., a person entering or exiting a car or building, a person walking or running, a person kneeling, jumping, bending
Activity	A composition of multiple events or actions. • e.g., a vehicle making a u-turn, a person digging a hole

The program will focus on a set of actions, events and activities that are of priority interest to intelligence analysts

Priority Activities

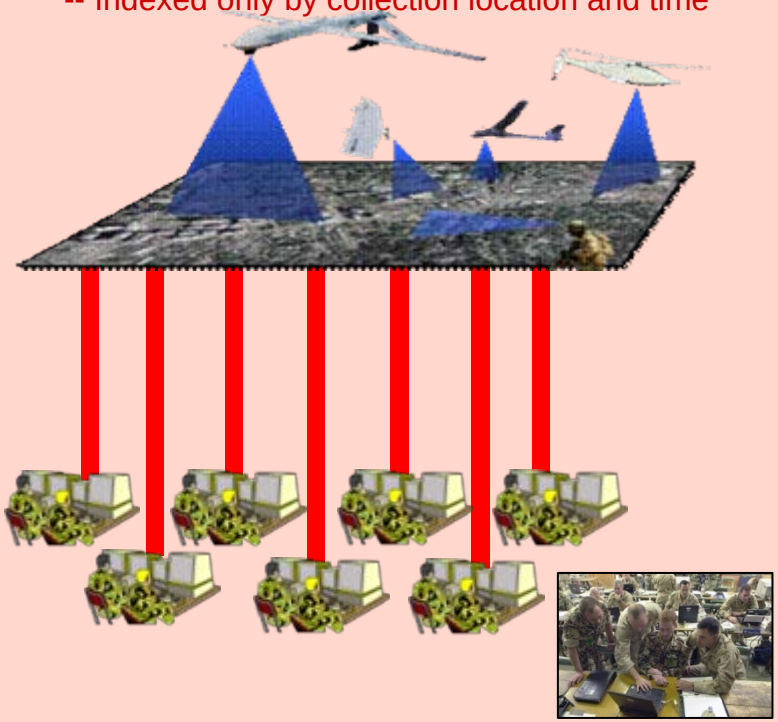
- Actions, events and activities VIRAT will address include, *but are not limited to*, the following:

Single Person	Digging, loitering, picking up, throwing, exploding/burning, carrying, shooting, launching, walking, limping, running, kicking, smoking, gesturing
Person-Person	Following, meeting, gathering, moving as a group, dispersing, shaking hands, kissing, exchanging objects, kicking, carrying together
Person-Vehicle	Driving, getting-in (out), loading (unloading), opening (closing) trunk, crawling under car, breaking window, shooting/launching, exploding/burning, dropping off, picking up
Person-Facility	Entering (exiting), standing, waiting at checkpoint, evading checkpoint, climbing atop, passing thru gate, dropping off
Vehicle	Accelerating (decelerating), turning, stopping, overtaking/passing, exploding/burning, discharging, shooting, moving together, forming into convoys, maintaining distance
Other	VIP activities (convoy, parade, receiving line, troop formation, speaking to crowds), riding/leading animal, bicycling,

Operational Context: Real-time Monitoring & Intel Analysis Search and Retrieval

Today:

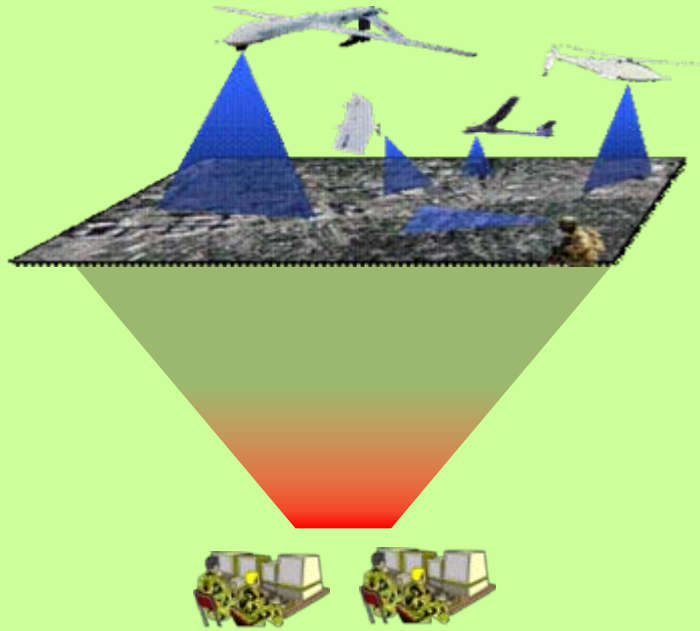
- Analyst overload from too many pixels
- Streaming video with manual monitoring (normal)
  - -- Limited to rewind/replay capability
  - -- See once, act now or lose opportunity
- Archived video with manual review (rare)
  - -- Search with fast forward/rewind
  - -- Sparse (if any) annotations WRT content
  - -- Indexed only by collection location and time



Tomorrow:

- Critical video content gets to the right analysts
- Real-time & archive content-based search
  - - Find matches that contain activities, scenes and objects
  - - Receive alerts on matches in streaming video – act smartly
  - - Quickly retrieve matches from archives - perform forensic analysis
  - - Exploit millions of frames of motion imagery – deliver actionable intel

VIRAT



System View: Automatic and Iterative Querying of Large Video Stores

Streaming Data
(from Predator, Raven, GH, etc.)

Archived Data
(from local, regional, or joint repositories)

Raw Motion Data

Example Clip +
Search Filters
(from available list or new video)

Existing Metadata Processor

Data w/text indexed

Existing Geo-spatial Registration Processor

Preprocessed Data and Example

Content Descriptor

Primitives Library

Data w/descriptors

Activity and Object Indexer

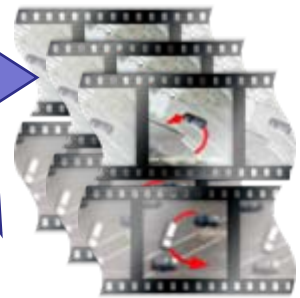
Data stored with descriptors

Indexed Data Store
e.g. DCGS-A, CALA, IDC

Activity and Object Searcher

Interactive Query Refinement Module

Video clips that match descriptors of query



Video clips that match index and video features and Alerts

Video clips that match index, features, and detailed appearances

VIRAT

Data Flows
- Indexing Flow
- Retrieval Flow

Example Scenario

INPUTS

Raw Full Motion Video (streaming, cached, or legacy archive)

INPUT: Standing Alert or Retrieval Query

Example Clip: Car making u-turn

Time Period: 12 hours (2100010204 – 0900010304)

Area: 4 km^2 with center at
33º 17’ 53.98” N
44º 21’ 36.35” E

VIRAT SYSTEM

Existing Metadata Processor:

Process lat/lon, date/time, and viewpoints in streaming video metadata

Data with text indexed

Existing Geo-spatial Registration Processor:

Geo-register incoming streaming video and compare with coordinates specified in input query.

Preprocessed data and query with example

Content-based Descriptor Analyzer:

Mid-level descriptors:
1. Tracks
2. Instantaneous velocity
3. Acceleration

Data with descriptors

Activity and Object Indexer:

Tagged activities: cars moving, turning, changing lanes, stopping, making u-turns, etc.

Activity and Object Searcher:

Find cars that stop quickly and start again quickly
1. Rapid deceleration
2. Instantaneous velocity = 0
3. Rapid acceleration

Interactive Query Refinement Module:

1. Remove clips with cars stopped in traffic

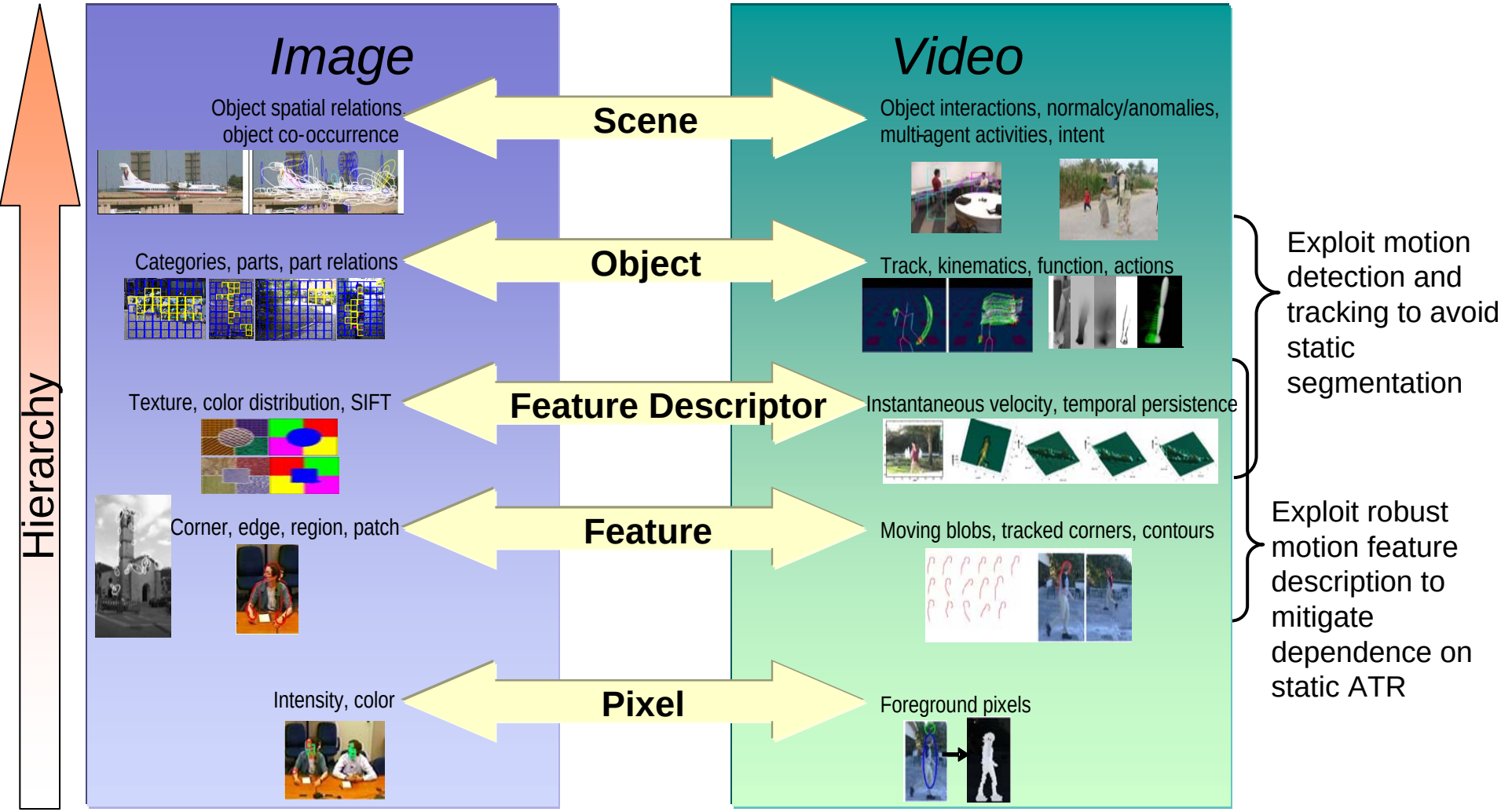
OUTPUTS

Data stored with descriptors

Video clips and alerts showing cars making u-turns or stopped

Video clips that show cars making u-turns or stopped (excluding those stopped in traffic)

Space-Time Descriptors Can Extend Traditional Image Processing



Shift exploitation paradigm from image-based to video-based

Special Challenges

- **Multi-source**
  - Targeted Sensors – Airborne initially
    - Predator, other UAVs
    - Evolve to include ground-based sensors
- **Sensor factors**
  - GSD
  - Frame rate
  - Viewpoint
  - Range
  - Platform motion
  - Geo-reference errors
  - Panchromatic, color, IR
- **Variations in scene conditions**
  - Urban vs rural terrain
  - Illumination
  - Weather
  - Atmospherics
  - Obscurations

Technologies NOT Sought

The VIRAT program will not support the development of new algorithms for:

- tracking,
- moving target detection and indication,
- image-based change detection,
- image-based anomaly detection,
- motion pattern learning,
- geo-registration, and
- sensor fusion.

Note: While it is expected that such algorithms may be useful to VIRAT, the system will use existing capabilities in these areas and will not depend on anticipated advances.

The VIRAT Program will not fund or use any of the following:

- face recognition,
- gait recognition,
- human identification, or
- any form of biometrics.

Note: Proposals involving the development of these algorithms will be rejected by the DARPA Program Manager.

Task 1: Algorithm Development and System Integration

- **Offerors must be comprised of a single team that creates an end to end integrated system**
- **Key technical challenges for algorithm development**
  - ***Robust event and activity representations***
  - ***Efficient indexing of full motion video archives***
  - ***Interactive query refinement for archival retrieval***
- **System integrator responsible for overall end-to-end architecture**
  - **Team member acting as System Integrator must be identified in the proposal**
  - **Responsible for end-to-end architecture and all system engineering issues**
    - **(e.g., input-output interfaces, state-of-the-art preprocessing of the data (e.g., stabilization and geo-registration), and the establishment of standards for data and algorithm interoperability)**

Use today to identify potential teaming partners!

Task 2: Performance Evaluation

- **Responsible for evaluating the systems and components developed under Task 1**
- **Main challenges:**
  - Create a test environment that is capable of assessing, quantifying, and scoring all system and component software
  - Design the experimentation protocols used for testing
  - Conduct the actual evaluations of all VIRAT software in an *independent and objective* manner

Task 2 is a separate effort and will have a team that is independent of Task 1 participants

Two Important Points

- **All software, software documentation, and technical data developed under VIRAT will be provided with unlimited rights to the government**
  - Any non-Commercial supporting software code, such as libraries, development environments, or runtime environments, which are required for installation, compilation, or execution of the VIRAT software should have unlimited or government purpose rights.
- **Patent rights to contractors**
- **The VIRAT program will utilize both UNCLASSIFIED and CLASSIFIED data (Secret-level only)**

Schedule – 3 Phases

Both tasks go across all phases of the program

- **Phase 1: Prototype Algorithm Development and System Design**
  - Demonstrate the establishment of accurate real-time alerts against streaming data and accurate retrieval from a video repository.
- **Phase 2: Algorithm Refinement and Optimization and System Integration**
  - Improve on accuracy and efficiency while simultaneously accommodating a larger set of events and activities, an increased video rate, and an expansion of the archive size.
- **Phase 3: Integration, Demonstration, and Transition**
  - Demonstrate rapid refinement of query results and the capability to accommodate complex searches that include, multiple, dynamic events within a single query

- ***Two performance evaluations per phase (6 month intervals)***
- ***Go/No-go evaluation 3 months before end-of-phase***
- ***Periodic PI meetings (typically at 6 month intervals)***

Go/No-go Metrics

Metric	Phase 1	Phase 2	Phase 3
$P_{D\ Retrieval}$	85%	90%	95%
$FAR_{Retrieval}$	8 (per hour per stream)	4 (per hour per stream)	2 (per hour per stream)
Speed of Retrieval	60 sec	45 sec	30 sec
$P_{D\ Streaming}$	75%	85%	95%
$FAR_{Streaming}$	12 (per hour per stream)	6 (per hour per stream)	2 (per hour per stream)
Change Latency	1 sec	1 sec	1 sec
Addition Latency	10 min	5 min	1 min

Archived Retrieval
Streaming Video
Overall System

Each proposal must address how it will ensure the attainment of the phase metrics specified

System Parameters

	Phase 1	Phase 2	Phase 3
Activities	10	30	60
Sources of Video	Predator Day TV & IR	Multiple UAVs	Ground based and all airborne
Size of Video Database	2 hours	20 hours	200 hours
Pixel Rate	4.5 MPixels/sec	9 MPixels/sec	58 MPixels/sec
Number of Alerts*	1	3	5

** Number of simultaneous inputs per video stream to generate alerts against*

These parameters are in addition to the Go/No-go metrics

Additional Performance Criteria

Archived Retrieval	
Robustness	Range over which sensor factors and scene conditions can be varied while maintaining both precision and recall within 10% of their maximum. Wider ranges are better.
Compactness	Size of the representation for activities. Smaller is better.
Temporal Accuracy	The fraction of correct coverage of a returned event or activity interval relative to ground truth interval length minus a penalty term of the fraction of incorrect. Higher is better.
Archive Expansion	The percent change in system performance for an increase in the size of video repository. Lower is better.
Feature Set Extension	The amount of time it takes to re-index the repository after a change in the underlying feature extraction process that introduces new elements to index. Lower is better.
Relative Rank	The average similarity score of correct detections divided by the average similarity score of false alarms. Higher is better.
User Feedback Tuning	The number of iterations with the user needed to achieve criteria performance. Lower is better.
Streaming Video	
Robustness	Range over which sensor factors and scene conditions can be varied while maintaining P_D within 10% of its maximum. Wider ranges are better.
Latency to Alert	The time it takes for a correct alert to be raised. Faster is better.

Other Desirable Characteristics

- **Ability to efficiently represent and retrieve objects and scenes as well as activities**
  - *Strong performance on static image retrieval*
- **Algorithms that broadly generalize across disparate data sources**

BAA PROCESS

- BAA and any amendments posted in FEDBIZOPPS
- BAA covers all info needed to propose
- TIME PERIOD – BAA is open for **45 days from Industry Day**
- Instructions are detailed in the BAA (**Follow closely**)
- **Following the proposal instructions assists the evaluation team to clearly understand what is being proposed and supports a timely negotiation.**
- **ALL** questions to BAA08-20@darpa.mil
- All interested/qualified sources may respond
- Foreign participants/resources may participate to the extent authorized by applicable Security Regulations, Export Laws, etc.
- Government agencies/labs, FFRDC's, can respond unless otherwise restricted from doing so by law/regulation and/or agency specific policy

BAA PROCESS

- Be aware:
  - Organizational Conflict of Interest & Procurement Integrity language
  - Central Contractor Registration (CCR), Online Representations and Certifications Application (ORCA), & Wide Area Workflow (WAWF)
  - Export Control language (ITAR)
  - Subcontracting Plan Requirements
  - Data Rights Assertions - Assert rights to all technical data & computer software generated, developed, and/or delivered to which the Government will receive less than Unlimited Rights
    - Assertions that apply to Prime and Subs
    - Use defined “Basis of Assertion” and “Rights Category”
    - Justify “Basis of Assertion”
    - This information is assessed during evaluations

BAA PROCESS

- EVALUATION/AWARD
  - Government reserves the right to select for award all, some, or none of the proposals received and to award without discussions
  - Government anticipates making multiple awards
  - No common Statement of Work - Proposals evaluated on individual merit and relevance as it relates to the stated research goals/objectives rather than against each other
  - Only a duly authorized Contracting Officer may obligate the Government

BAA PROCESS

- COMMUNICATIONS
  - Prior to Issuing BAA – No restrictions, however Gov't (PM) shall not dictate solutions or transfer technology
  - After Issuing the BAA – No restrictions, however Gov't (PM/PCO) shall not dictate solutions or transfer technology
  - After Receipt of Proposals – Government (PM/PCO) may communicate with offerors in order to understand the meaning of some aspect of the proposal that is not clear or to obtain confirmation or substantiation of a proposed approach, solution, or cost estimate
  - Informal feedback may be provided once selection(s) are made

BAA PROCESS

- Make proposals valid for 120 days
- Include detailed cost breakdown for subs whose costs are or exceed 10% of the total proposed cost. These detailed sub cost proposals may be submitted directly from the sub.
- Teaming page URL is modified to: https://www.csc-ballston.com/baa/VIRATteaming.htm

BAA PROCESS

- IP to include any non-Commercial supporting software code, such as libraries, development environments, or runtime environments, which are required for installation, compilation, or execution of the VIRAT software should have unlimited or government purpose rights.

Contacts

General Questions: BAA08-20@darpa.mil

Fax for Questions: (703) 807-4984, Attention: Dr. Mita Desai

FAQs: http://www.darpa.mil/ipto/solicit/solicit.asp

Teaming Page:
https://www.csc-ballston.com/baa/VIRATteaming.htm

Important Dates

BAA Released	**3 Mar 2008**
Industry Day	**27 Mar 2008**
Last Date for Questions	**5 May 2008** one week before due date
Register in TFIMS	**5 May 2008** one week before due date
Initial Due Date	**12 May 2008**
Final Due Date	**2 Mar 2009**
Source Selection	**June 2008**